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Publications of the Disaster Prevention Research Institute of Kyoto University

The Disaster Prevention Research Institute publishes the results of its research activities in annuals (in Japanese) and bulletins. The annual is published at the end of an academic year, April to March. One volume of the bulletin, corresponding to an academic year, is divided into five parts. Each of the first four parts includes several papers, and the fifth part comprises the abstracts of papers published by staff members of the Institute in the academic year.

The fifth part will be discontinued after the present issue. An outline of the research activities at the Institute shall be found from the titles of the published papers which are to appear at the end of the fourth part of the bulletin.

Discussions and the request for a copy of a paper should be addressed to the authors at the Disaster Prevention Research Institute, Kyoto University, Gokasho, Uji, Kyoto, Japan.

CONTENTS

An Analysis of Past Earthquakes in the Kansai District and Related Problems

By Soji YOSHIKAWA

Architecture and Society,
Vol. 52, September, 1971, pp. 34–37 (in Japanese).

Abstract

152 earthquakes occured in the Kansai district between 416 and 1970. The periodicity of these earthquakes are discussed in relation to each focal region and the characteristics of earthquake damage at the urban area were described. Main seismic active areas are divided into three regions, that is, Yodo area, Ikoma-Kongo area and off *Kii* area. The earthquake motions at the base rock of the urban area presumed by these earthquakes are different depending on the magnitudes and hypocentral distances. Taking the example at Osaka, the following earthquakes are supposed to be dangerous.

(1) Mag. 7, epicentral distance ca. 30 km.
(Max. Acc.$\simeq$0.1$\sim$0.2 g, $T_p\simeq$0.2$\sim$0.4 sec.)

(2) Mag. 7.5, epicentral distance 50$\sim$100 km.
(Max. Acc.$\simeq$0.05$\sim$0.15 g, $T_p\simeq$0.4$\sim$0.6 sec.)

(3) Mag. 8.5, epicentral distance$\geq$100 km.
(Max. Acc.$\simeq$0.05$\sim$0.15 g, $T_p\geq$0.6 sec.)

The relations between earthquake damage and the expected earthquakes are discussed in each case of epicentral distance and magnitude in which the effects of the motions on the base rock, the surface geological structure and the dynamical characteristics of the structure are largely concerned.

Measurement of Physical Constants of Shirasu (Whitish Grey Welded Tuff) Ground

By Eizaburo Yoshizumi, Soji Yoshikawa, Chugoro Satoh and Takemi Shibuya

Proceedings of the 7th Symposium on Rock Mechanics, February, 1972, pp. 56–60 (in Japanse).

Abstract

For the purpose of expressing the properties of soft ground, the N-value derived from the standard penetration test is in wide use. However, if the same physical constants which are being used for the evaluation of rock (Poisson's ratio, rigidity, dynamic Young's Modulus, electric resistivity, etc.) could be simply determined for this type of ground also, a more exact evaluation of the ground could be made and this data could be used effectively in design and construction execution.

With this in mind, a method was devised for the simultaneous in-situ measurement of penetration resistance, electric resistivity and the velocity of propagation of seismic wave by utilizing the sounding car penetration mechanism which has been used heretofore in soil testing by pushing into the ground a newly built measuring device which incorporates a load cell, electrode and pickup.

The main results obtained are as follows:

The propagating of P and S wave varies in a pretty wide range depending on the position and direction, however, when taken as a whole the following tendencies were observed:

(1) The velocities of P wave are 190–200 m/sec. and those of S wave 90–130 m/sec. at the undisturbed places of Shirasu ground in the upper layer. The velocities of P and S waves in the lower layer are about 500 m/sec. and 230 m/sec., respectively, inserted by intermediate layer whose velocities of P and S wave are 300 m/sec. and 150 m/sec. respectively at some places.

(2) At the filled ground by Shirasu the propagating velocities of P and S waves are about 300 m/sec. and 70m /sec. respectively and no increase of velocity with depth was found.

Determination of Grouting Effectiveness in the Rock Foundation of a Dam

By Eizaburo Yoshizumi, Soji Yoshikawa, Tsuyoshi Sugano
Chugoro Satoh and Takemi Shibuya

Proceedings of the 7th Symposium of Rock Mechanics,
February, 1972, pp. 66–70 (in Japanese).

Abstract

Among the many methods which have been devised for the determination of grouting effectiveness, the use of seismic prospecting and electrical measurements has been one of the most effective. That is to say, when making a determination from a macro viewpoint of the degree of grouting effectiveness in a grouted area, the degree of effectiveness can be expressed by performing before and after the grouting operation seismic prospecting and measurements of electric resistivity on the location in question from the ground surface or from within a tunnel. On the other hand, when making a detailed determination from a micro viewpoint of the condition of the rock together with the grout structure, these can be expressed by performing before and after the grouting operation measurements of the electric resistivity of the rock by utilizing the boring hole itself or a boring hole adjacent to that hole.

The main results obtained are as follows:

(1) As a whole, the increase of propagating velocity both of P and S wave were measured after grouting.

(2) A significant variation of Poisson's ratio was not found.

(3) From the above measurement, it was found that the large cracks were filled by grouting, however, small ones still remained. Therefore, for the improvement of dam base more grouting would be required so that the increase of S wave velocity would be marked when compared with that of P wave.

(4) The grouting effectiveness depends on the original rock conditions. When the crack contains clay, gouting is not effective.

(5) The rock characteristics in the grouted area are still softer than that of hard rock at the same place of a dam site.

Source Process of Deep and Intermediate Earthquakes as Inferred from Long-Period P and S Waveforms
2. Deep-focus and Intermediate-depth Earthquakes around Japan

By Takeshi MIKUMO

Journal of Physics of the Earth,
Vol. 19, No. 4, 1971, pp. 303–320 (in English).

Abstract

The dynamical processes at the source of eleven deep-focus and intermediate-depth earthquakes that occurred around Japan have been investigated from the analysis of long-period *P* and *S* waveforms.

The recorded *P* waveforms have been equalized at some distance around the focal region to get the source function, eliminating the combined effects of wave propagation in the earth and of the seismograph characteristics. It is found that the source process times derived from the source function, as well as from the recorded first half-periods, indicate some azimuthal dependence with respect to the orientation of one nodal plane and of the null vector, in most of the earthquakes. This dependence is interpreted as a result of shear faulting over a finite fault area, and used to determine the slip plane, slip direction, fault length and width. The sismic moment and the average dislocation over the plane are evaluated from *P* wave amplitudes together with the estimated fault dimension.

A close agreement in general features between the recorded and synthesized waveforms including the absolute amplitudes of both *P* and *S* waves supports the above shear dislocation model. The overall distribution of the orientations of the slip planes and slip vectors of these earthquakes does not seem to be definitely related to the local dip or strike of seismic zones in this region.

The calculated stress drops during these earthquakes, together with some available data, appear to show a gradual increase with focal depths down to 400 km. A tentative interpretation of this increase is that the stress drop might be related, at least qualitatively, to partial loss of the intrinsic (cohesive) shear strength of the material under increasing hydrostatic pressures, if these earthquakes are caused by brittle fractures in the lithosphere.

Inferences of a Layered Structure from S Wave Spectra Part 1. Theoretical Considerations of S Wave Spectrum Method

By Tuneto KURITA and Takeshi MIKUMO

Journal of Physics of the Earth,
Vol. 19, No. 2, 1971, pp. 93–110 (in English).

Abstract

A method is described to infer a layered structure from the amplitude ratio of the vertical to the horizontal component of SV waves totegher with the phase difference between them, and also from the corresponding relations between SH waves and the horizontal component of SV waves. The behaviors of these frequency-dependent functions for various models with different layer parameters are investigated, and their applicability to inference of the structure is discussed.

It is shown that the S wave spectra will be useful to test the appropriateness of probable models derived from P wave spectra and other information, if good records from deep-focus shocks with appropriate epicentral distances are analyzed.

Inferences of a Layered Structur from S Wave Spectra Part 3. SH and SV Wave and Some Related Problems

By Takeshi MIKUMO and Tuneto KURITA

Journal of Physics of the Earth,
Vol. 19, No. 3, 1971, pp. 243–257 (in English).

Abstract

An attempt is made to infer the crust-mantle structure in several regions of Japan and North America from the spectral amplitude ratio and the phase difference between SH and SV waves from deep shocks.

It is found that the spectral behaviors of well-recorded S waves give support to some of the probable structures derived from P wave spectrum and some other information, suggesting characteristic differences in the tectonic structures; the possible existence of a rather thick intermediate layer having velocities between those appropriate to the lower crust and the normal mantle over three regions of Japan; and of a typical continental structure and oceanic crust in selected two regions of North America.

The structures inferred for central and eastern Japan can explain satisfactorily the observed phase velocities of Rayleigh waves, but the Love wave velocities are significantly higher than those expected from the structures. If the high velocities of Love waves are not a result of higher mode contamination, the observed inconsistency may be accounted for either by anisotropic (transversely isotropic) mantle or laminated mantle models, but the spectral behaviors of S waves appear to favor the former model.

On the Nature of the Occurrence of Intermediate and Deep Earthquakes
2. Spatial and Temporal Clustering

By Kazuo OIKE

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 21, Part 1, No. 184, September, 1971, pp. 43–73 (in English).

Abstract

Spatial and temporal clustering of intermediate and deep earthquakes have been studied from data of the location, depth, origin time and magnitude of earthquakes deeper than 100 km.

Multiplets frequently occur in the intermediate zone of the South Sandwich Islands, Colombia, the West Indies, the Aleutian Islands, Celebes Island, the Banda Sea, New Hebrides and the Hindu-Kush regions and in the deep zones of South America, Java-Banda Sea, Santa Cruz and the Fiji Islands region. These regions are characterized by the bending or the contortion of the descending lithosphere. In contrast, they are scarcely found in Central America, the Kuril Islands, Japan, Mariana or the Ryukyu Islands.

Hypocenters of shocks of each multiplet distribute on a long and slender plane in space. The largest shock in a multiplet is located at the extremity of the plane in almost all cases. Moreover, the shocks of each multiplet which occur in an area show the characteristic directional distribution. These distributions are strongly related to the distribution of the directions of the principal axes of stresses in the concerned regions.

On the analogy of the mechanism of the aftershock occurrence of shallow earthquakes, these characteristics of multiplets mean that small shocks of a multiplet are generated by the local concentration of the stress energy which is produced by the occurrence of a main fault plane of the largest shock.

From the time sequence of each multiplet it is found that there are some cases in which the largest shock occurs at the beginning of the series, that is, the aftershock type, but in many cases the multiplet type sequences are found. In cases of large shallow earthquakes a clear pattern of a main shock-aftershock sequence is generally found. This difference between the time sequence of shallow earthquakes and intermediate and deep earthquakes seems to be the reflection of the different physical conditions between the shallow zones and the deeper zones.

On the Nature of the Occurrence of Intermediate and Deep Earthquakes
3. Focal Mechanisms of Multiplets

By Kazuo OIKE

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 21, Part 2, No. 189, November, 1971, pp. 153–178 (in English).

Abstract

The relations between the distribution of the foci of foreshocks and aftershocks and the focal mechanisms of main shocks in twety-five multiplets have been investigated.

Foreshocks and aftershocks always occur on one of the nodal planes of a main shock. This is explained by the characteristics of a shear fault plane which has a strong tendency to propagate itself.

Considering these properties of multiplets, the slip planes of main shocks are determined from the analyses of the distribution of foci. It is concluded that the slip planes of intermediate and deep earthquakes are generally parallel to the strike of the seismic plane in the regions, and in intermediate earthquakes the cases in which a deeper side block slips down are predominant.

Two doublets with remarkably short time intervals are analyzed in detail and the upper limit of the propagating velocity of fractures in deep foci is determined at being 4.7 km/sec.

Distribution of Earthquake Genèrating Sgtresses Obatined by Smoothing the First Motion Patterns

By Kazuo OIKE

Journal of Physics of the Earth,
Vol. 19, No. 3, September, 1971, pp. 181–198 (in English).

Abstract

The world wide distribution of the earthquake generating stress of intermediate and deep earthquakes has been obtained from the smoothed radiation patterns of P waves of groups of earthquakes in fifty-one seismically active regions.

Data used in this study were taken from the Bulletins of the International Seismological Center, 1964 and 1965 for the very active regions; and for the regions where a few intermediate and deep earthquakes occurred data from the Earthquake Data Reports of the U.S. Coast and Geodetic Survey, 1966–1969, were added.

The smoothed rediation patterns of the Kuril-Japan, the Izu-Marianas and the Tonga-Kermadec regions determined from only two years' data showed satisfactory agreement with the patterns obtained for larger earthquakes by many seismologists.

In almost all regions the axes of maximum pressure align themselves with the dip of the seismic plane. The direction of the horizontal component of the axis of maximum pressure in each region was compared with the direction of differential movement between two blocks computed by Le Pichon, and they agreed well with each other except in the following regions. In the South America region, the horizontal components of the axes of maximum pressure lie in the east-west direction. The patterns of intermediate earthquakes of the Chile-Peru border region, the Honshu region of Japan and the New Hebrides region show that the axes of maximum tension align themselves with the dip of the seismic plane.

Distribution of Stresses and Dynamic Displacements Around a Fault

By Kazuo OIKE

Zisin (Journal of the Seismological Society of Japan),
Vol. 24, No. 4, December, 1971, pp. 318–334 (in Japanese).

Abstract

The distributions of stresses around a elliptical fault plane in an infinite homogeneous elastic medium were calculated. There are some regions where shearing stresses are not decreased but significantly increased. It indicates that a shear fault has a strong tendency to propagate itself and this corresponds to the occurrence of aftershocks. From the change of each component of stresses it is expected that large aftershocks which occur on and around the x_1 and x_2-axis have similar mechanism to that of a main shock, and aftershocks in other regions have different mechanisms.

Dynamic displacements in the near field around a propagating fault were calculated for the various types of faulting. The different characteristics of the fault are reflected in the wave forms related to far field terms. Some of the results given by Haskell (1969) were checked under the same conditions as his calculations and essentially different results were obtained.

The Observation of Microtremors Correlated with the Existence of Cracks at the Landslide Area

By Tatsuhiko WADA, Kosuke KAMO, Tamotsu FURUZAWA and Kensuke ONOUE

Bulletin of the Disaster Prevention Research Institute, Kyoto University, Vol. 21, Part 3, No. 193, March, 1972, pp. 217–226 (in English).

Abstract

At the landslide area many cracks are widely found. The spectrum of microtremors may be affected by these cracks which separate the gorund structure into blocks in the lateral direction. Therefore, in order to interpret the observational result of microtremors at landslide area, it may be necessary to confirm the relation between the existence of cracks and the vibrational characteristics of such ground.

With these suppositions, the observations of microtremors with three components of seismographs were carried out twice at the Kamenose landslide area. During the first observation, the region where cracks appeared very clearly on the ground surface were surveyed for investigation of the effect of the existence of cracks in the ground structure on microtremors. On the basis of that result, the latter observation was carried out over a large region of the landslide area where the cracks may be either covered or unknown.

The records played back from the data recorder were classified into various frequency domains using an analogue filter with an attenuation rate of 30 db/oct., and the wave form and amplitude at each site were compared. And then, Fourier spectral analysis were made from the 20 Hz low-passed records. From the Fourier amplitude spectrum for each site, the microtremors may be classified into three kinds of frequency type: high frequency type (above 10 Hz), medium frequency type and low frequency type (lower than 1 Hz). The high frequency type of tremors may be affected by some local source near the ground surface and may not reflect the main structure of the landslide area.

The amplitude spectra of the medium frequency type at the points where cracks appeared clearly are much larger than other poits. Moreover, the particle motions are strongly polarized in the direction perpendicular to a crack. Therefore, it is suggested that the vibrational characteristics of the medium frequency range of tremors depends on the ground structure which has been separated into many blocks by the development of cracks. For low frequency types the waveforms of the vertical components of each point in a tripartite net coincide entirely with each other, together with a small phase lag. It seems certain that these type of microtremors have reflected the characteristics of the global structure in Kamenose landslide area.

Elastic-Plastic Behavior of Steel-Reinforced Concrete Members

By Minoru WAKABAYASHI and Takeshi YAMAGUCHI

Proceedings, Annual Meeting of Architectural Institute of Japan,
November, 1971, pp. 777–778 (in Japanese).

Abstract

An experimental research was carried out to investigate the ductility and strentgh of steel-reinforced concrete members subjected to axial compression and shear. With the type of shear loading (monotonic or 3 different types of cyclic) and ratio of axial compression to the yeild load used as experimental parameters, 12 specimens with identical cross sectional properties were prepared. The size of a square concrete gross section was 150×150 mm and rolled steel H-section H-$100 \times 50 \times 4 \times 6$ was used. A 10 mm steel deformed bar was used for reinforcement and 3 mm for shear reinforcement. 0, 30 and 50% were chosen for axial force ratios. For cyclic loading cases, the first series was controlled by a constant displacement amplitude increment at unloading points in alternately repeated loading, the second by constant shear load increment, and the third series was again controlled by a constant displacement increment in one-side repeated loading.

Assuming linear elastic-perfectly plastic stress-strain relationship for steel, nonlinear elastic-perfectly plastic for concrete inside stirrups and nonlinear elastic-negative linear plastic for concrete outside stirrups, theoretical hysteresis loops were obtained. For unloading in concrete, linear relationships between stress and strain was assumed, and its slope was assumed to decrease depending on the strain at the unloading point.

It was concluded that members with 50% axial force ratio showed very small deformation ability after it reached maximum shear strength. This phenomenon was more clarified in the case of cyclic loading. Comparison of theoretical results for monotonic loading with the experimental one showed good agreement except for the case of 50% axial force ratio. A discrepancy appeared on the stiffness of the members subjected to cyclic loading.

Analysis of Lateral Buckling Strength of Trusses by Energy Method

By Minoru WAKABAYASHI and Fumiko NISHIMURA

Proceedings, Annual Meeting of Architectural Institute of Japan,
November, 1971, pp. 309–310 (in Japanese).

Abstract

In order to reduce the computational tediousness to obtain the lateral buckling strength of truss member by searching for the load at which the stiffness matrix derived based on buckling slope-deflection equations becomes singular, the method of evaluating the effects of diagonal and tension chord members on the buckling strength of compression chord members by energy method was applied on several examples.

The change of total potential energy due to buckling deformation is composed of contributions due to; 1) external load, 2) bending of upper and lower chord members, 3) twisting of upper and lower chord members, 4) bending and twisting of diagonal members. Assuming that the displacement and twisting angle distributed along the longitudinal axis of the compression chord member can be expressed by sinusoidal functions, the buckling loads of trusses subjected to different types of bending moment distribution (uniform bending moment, a concentrated load at mid-span, a bending moment at one end or anti-symmetrical bending moment) were analysed.

The numerical results were compared with other investigator's experimental and theoretical results in which some terms were neglected. It was concluded that the design formula based on the method in which the deformations of both upper and lower chord members were considered while the derivatives of those were neglected seemed to be conservative according to the present results. However, the numerical results are known to be highly dependent on the assumed buckled configuration of the member, and it is difficult to give a mathematical exression that well approximates the real buckling load, particularly in the case with varying axial compression.

Vibrational Characteristics of a Coupled Rigid Bodies System on an Elastic Ground

By Takuji KOBORI, Ryoichiro MINAI and Kaoru KUSAKABE

Reports of the Architectural Institute of Japan
(KINKI Sub-Division), May, 1971, pp. 13–16, (in Japanese).

Abstract

Many studies have been recently done on the dynamic characteristics and the earthquake response of ground-structure systems by taking into consideration the interaction effect of the elastic ground. In most of these studies, it is supposed that a single structure exists on the ground. However, the structure may actually be surrounded by many other structures having various dynamic characteristics. Therefore, it may be necessary to take account of the coupling effects of the adjacent structures, which stems from the energy transmission through the supported ground, on the dynamic characteristics and the earthquake response characteristics of the structures considered. In this paper, as the most fundamental problem of the coupled vibrations of the ground-multi-structures system, the force-displacement transfer functions of a rigid bodies system on an elastic ground are discussed. The dynamic characteristics of the ground are represented by the force-displacement transfer function, which is called the dynamic ground compliance of a finite exciting area on an elastic ground and of an arbitrary point or domain of the ground. In general, if a finite area on the ground is excited in a certain direction, the point of the ground may respond dynamically in three dimensional locus. For the sake of simplicity, however, it is assumed that the force and displacement components in other than the exciting direction can be neglected. The numerical analysis is carried out for the case of the two same square rigid bodies system on an elastic half-space, in which one body is excited in the horizontal direction and the other is free. The results are shown graphically in non-dimensional form as the amplitude and phase characteristics for both the active and passive bodies together with the results in the case of the same single body on the elastic half-space.

As the results of the numerical analysis, it is found that when increasing the mass ratio defined by the ratio of the mass of a rigid body to the product of the density of the ground and the cubic power of the reference length of the mass, the amplitude characteristics of the active body increase near the resonance frequencies as compared with those for the single body and that the amplitude characteristics of the passive body are considerably amplified in comparison with those of the same point on the free surface, particularly in the vicinity of the resonance frequencies and for the large mass ratio. Also, it is found that the phase characteristics of the active body are little affected by the existence of the passive body, but those of the passive body are considerably different from those of the free surface except for the low frequency range. These results may be interpreted by the energy conservation effect due to the power flow between the two bodies having the identical dynamic characteristics.

Vibrational Characteristics of a Full-Scale Stell-Frame Test Structure

By Takuji KOBORI, Ryoichiro MINAI and Teruo KAMADA

Proceedings of the 8th Symposium on Natural Disaster Science,
October, 1971, pp. 161–164, (in Japanese).

Abstract

A considerable number of dynamic tests and earthquake response observations of actual structures have been done in order to determine the dynamic properties and earthquake response characteristics of structures and to obtain the mathematical model of the ground-structure system by which the dynamic behaviour of structures during strong earthquakes is predicted. The dynamic tests and earthquake response observations of actual ground-structure systems are essentially important for the sound progress of earthquake engineering, because there may not be, at the present stage, such a complete analytical method that can take account of the complexities of the material properties and structural configurations of the actual ground-structural system.

A five-story full-scale test structure was built at the Uji campus of Kyoto University in order to perform extensively experimental study on the problems of structural engineering, especially to perform dynamic tests and earthquake response observation. To render the analytical consideration less difficult, the structure was constructed as simply as possible with steel frames and reinforced concrete slabs rectangular in plan, without walls and separated from any staircase.

In this paper, the basic properties of the structure, such as natural frequencies and the corresponding critical damping ratios and vibration modes are determined from the harmonic vibration test using a rotating eccentric weight exciter and from the spectral analysis of the microtremors of the structure. The first five natural frequencies and relevant basic properties are presented in regard to the translational vibration along the short principal axis of the structure.

Special attention is payed to the variations of the first resonance frequency and its mode shape with the level of excitations. The decrease of the resonance frequency is quite apparent when increasing the excitation level, and more than 20% decrease in the first resonance frequency is observed even for the small excitation level as compared with the elastic limit of the structure. These experimental results show the strong coupling of the elastic structure with the inelastic ground, because the vibration amplitude of the roof floor is less than 3 mm at the highest excitation level adopted in the tests, which means the structure remains undoubtedly within the elastic limit. From the variation of the first mode shape with the excitation level, this nonlinearity seems to be attributable to the inelastic dynamic characteristics of the ground, especially to the equivalent horizontal stiffness characteristics of the adjacent ground.

Because of the simplicity of the structure, its damping capacity is so small that the critical damping ratios determined from the dynamic tests are less than 1%. It may be considered that the main part of the damping capacity is not due to the structural damping but to the radiation damping of the ground.

Large Plastic Deformation of a Structure due to Impact — An Experimental Study on a Two-Storied Frame Subjected to Ground Shock —

By Minoru WAKABAYASHI, Taijiro NONAKA, Michio SHIBATA and Nobuyoshi TAKAGI

Proceedings, Annual Meeting of Architectural Institute of Japan, November, 1971, pp. 385–386 (in Japanese).

Abstract

An experimental study was made on the nature of the large permanent deformation of the columns in a single bay two-storied rectangular frame, under horizontal impact loading. The column specimens, which were made of steel plates, were rigidly connected by high strength bolts to the base and beam blocks. The ratio of the column width of the lower story to that of the upper one was varied from 1 to 1.9, in order to find the effect of column dimensions on the deformation pattern. Four wire strain gages were attached to the mid-height portion of each column. The dynamic restoring force of the frame was evaluated from the moment gradient of the columns which was determined by the wire strain gage readings. The frame specimen was set on a bifilar pendulum at rest, then the pendulum was struck by another input pendulum, and the column bases were subjected to impact motion. The relative displacement-time relations of beams were measured by displacement meters, and their outputs were compounded with the restoring-force records on an oscilloscope screen.

Experimental results indicated that the dynamic restoring-force characteristics depended greatly on the impact velocity and that the ratio of the dynamic strength of the frame to the static one was about 1.5 throughout this test.

Theoretical assesments were also made on the magnitudes of the final displacements of beams. The rigid-visco plastic analysis furnished a simple analytic solution on the safe side, and the elasto-visco plastic analysis, accomplished by a numerical calculation, showed a good consensus with the experimental results.

Liquefaction Process of Sand during Cyclic Loading

By Toru SHIBATA, Hiroshi YUKITOMO and Manabu MIYOSHI

Soils and Foundations, Japanese Society of Soil Mechanics and
Foundation Engineering, Vol. 12, No. 1, March, 1972, pp. 1–16 (in English).

Abstract

It is universally known that saturated loose sand exhibits the phenomenon of liquefaction when it is subjected to cyclic loading occurring at relatively short intervals. It may be postulated that the phenomenon is shear failure due to a decrease in internal friction resulting from this cyclic loading, and due to a decrease in effective stress in consequence of a rise in pore water pressure.

To date, numerous researches have been pursued on the liquefaction of sand in connection with the investigation of the possible disastrous effects of earthquakes upon soft ground. A review of the series of achievements by Seed et al. in thier researches reveals that the major factors for the development of liquefaction are (1) density of sand, (2) effective overburden pressure on sand, (3) magnitude of cyclic shear stress, and (4) number of stress cycles exerted by an earthquake.

In this paper, a series of quick cyclic shear tests on saturated sands of low density was made in the vibratory triaxial apparatus keeping the mean principal stress constant. In order to study in detail the process of liquefaction from the viewpoint of effective stress, the slow cyclic triaxial and simple shear tests were also made. Moreover, as an approach to the liquefaction of sand caused by irregualr cyclic stress, a series of special tests with varying amplitudes of shear stress were performed.
The main results based on these tests are as follows:

1. The pore water pressure increment which accumulates during one loading cycle before the onset of initial liquefaction may be expressed as a function of the octahedral shear stress and mean principal stress or that of shear stress and normal stress on the shear plane. This relation is likely to be applicable to the case of irregular stress amplitude which simulates the actual time-hitory of shear stress during an earthquake.

2. It has been pointed out previously that as the sample approaches the onset of initial liquefaction an unusual change in pore water pressure appears, i. e., the pore water pressure increases during unloading, and vice versa. In so far as Toyoura sand and glass beads used here are concerned, such an unusual change in the pore water pressure appears at the time when initial liquefaction occurs, and the angle of internal friction mobilized at that time has a close relation with the true angle of friction of granular materials.

3. The number of stress cycles requiered to cause the initial liquefaction may be expressed in terms of the ratio of cyclic shear stress to the mean principal stress. But as for the coefficients included in this expression, there remain uncertainties in their physical meaning for which further study would be required.

Experimental Study on the Horizontal Restoring Force Acting on the Substructure in Dry Sand Layer

By Hisao GOTO, Susumu YOSHIHARA and Masaru KITAURA

Proceedings of JSCE, No. 194, October, 1971, pp. 1~11 (in Japanese).

Abstract

In the laboratory experiments, in this study, the authors attempted to make direct measurements of the restoring force acting on the model substructure by means of a laod-cell, small pressure-cells and so on. To simulate the surface layers, three dry sand layers with different grain size distributions were formed using Toyoura Sand (U_c=1.3, D_{10}=0.15 mm), Soma Sand (U_c=1.7, D_{10}=0.45 mm) and Yasu Sand (U_c=2.6, D_{10}=0.22 mm).

Vibrating models had rectangular and circular sections with a hinge at bottom.

Experiments were practiced for the following three cases: (a) The top of the model in the sand layer was loaded statically and dynamically by a shaking table, in which the displacement of the model was contralled in the frequency range 0.005 Hz ~10 Hz. (b) The model was excited through the sand layer on a shalkng table, in this case, the top of the model was (fixed*) through a load-cell to a fixed point. In this experiment, the relation between forces acting on the model substructure was similar to that in case (a), but the sand layer had inertia force. (c) The model was excited by a small vibrator (its own weight=6 kg, maximum exciting force=about 100 kg) fixed at the top of the model in the sand layer.

The discussions of these data proved that, the tendency of the loading force (or reaction) applied to the top of the model and of vibrational earth-pressure acting on the model were very similar to each other. Since the model was designed so that the reaction and the earth-pressure would primarily represent the restoring force, the measured reaction and earth-pressure can be regarded as the restoring force.

The hysteresis loops of the restoring forces are of a frictional type when the displacement of the model is small, and of a slip type with friction when it is large. As the excitation frequency becomes high, the slope of the hysteresis curve in the neutral axis becomes small. The curves connecting the maixmum point (extreme curves) of the hysteresis loops are of a softening type with wide linear zones for small displacement but for large displacement they become of an even more softening type. Once the liquefaction of the snad layer due to large acceleration begins, the extreme curves become much more of a softening type and at last they trace descending curves.

In order to apply these experimental results to earthquake-resistant design, the restoring force characteristics have been represented by an empirical formula.

Storm Frequencies and Wind Load Problems

By Hatsuo Ishizaki

Proceedings of the 3rd International Conference on Wind Effects on Buildings and Structures, September, 1971, pp. III. 15-1-10 (in English).

Abstract

The paper consists of two parts. First the writer discussed the storm frequencies in Tokyo and Kyoto area based on the study of old documents, and found some periodicities in the frequency distributions of typhoons. The maximum occurrence of strong winds in a year is 4, and the minimum is, of course, none. The frequency averaged over 1200 years is about 0.5 per year — in other words, we have suffered from a storm every two years in Kyoto. The power spectrum computed from the frequency of storms for the above period exhibits peaks near the 5–6 and 11–15 year marks which approximately coincide with the sun spot cycle. Tokyo was struck by storms more frequently than Kyoto, but the individual typhoon in Kyoto appears to be more violent and bigger in scale than that in Tokyo.

Secondly, the wind profile is discussed as a fundamental problem of wind loads on structures. The power law of the wind profile above ground was theoretically compared with the logarithmic law and the following relations were obtained:

$$n=\frac{1}{\alpha}=ln\frac{z_1}{z_0}, \qquad \frac{v^*}{v_1}=\frac{k}{n},$$

where n and α are power law indices, z_1 is the reference height in the power law equation, z_0 the roughness length of the logarithmic law, v_1 the wind speed at the reference height, v^* the friction velocity and k von Karman's constant. Furthermore the mean wind speed ratio at the reference height with various ground surface roughness is estimated under simple assumptions.

Deformations and Vibrations of Some Actual Structures due to Wind

By Tatsuo MUROTA and Hatsuo ISHIZAKI

Proceedings of the 3rd International Conference on Wind Effects on Buildings and Structures, September, 1971, pp. IV. 49–1–10 (in English).

Abstract

Recently more precise estimations of wind effects on buildings and structures are becoming important. In order to estimate wind effects, it is essential to know the spatial and hourly wind pressure distribution on buildings and structures together with their corresponding oscillatory responses. For this purpose wind effect measurements on full scale structures have been made in several countries.

Here wind effect measurements were made on a steel-trussed TV-tower 160 m high in the urban district of Osaka. The tower has square sections of 14 m × 14 m up to 100 m. Mean wind speed, velocity pressure of wind and inclination response of the tower were measured in typhoon winds. The torsional oscillation was observed to be predominant and the necessity of taking the wind direction fluctuation into account was pointed out for the estimaton of the tower response. Spectral analysis of response was made and the characteristics of the tower oscillation were examined. Examples of the observed wind profile over the city were shown.

A Wind Tunnel Model Experiment of Wind Loading on Curved Roofs

By Hatsuo Ishizaki and Yuzo Yoshikawa

Bulletin of the Disaster Prevention Research Institute,
Kyoto University, Vol. 21, Part 4, No. 195, March, 1972,
pp. 247–263 (in English).

Abstract

For designing structures with suspended roofs, the knowledge of the characteristics of wind forces on them is most essential, because the effect of wind forces is more serious than on ordinary roofs. However little is known about the characteristics of wind forces on suspended roofs. Hence, an experimental study was carried out on two dimensional rigid roof models of three types in uniform flow wind tunnel.

These three types of models had the same span length of 50 cm: one was the flat roof type (Model–A) and other two were concavely curved roofs with maximum sag depths of 5 cm (Model–B) and 10 cm (Model–C). Static wind pressure distributions were obtained on roofs of five different wall heights in five different wind speeds. Dynamic wind pressures were measured on the three type roofs of 15 cm wall height in 10 m/s wind speed. The pressure sensors were the strain gauge type which can measure the pressure fluctuation up to 100 cps. The wind pressures were measured at eleven points along the central line of each model.

Static wind pressure distributions were affected by their sag depths and the difference of distribution form between the flat roof and the curved roofs was remarkably shown. The results of frequency analysis of dynamic wind pressure showed a broad peak of 5.8 cps in most cases and this value coincided with the nondimensional value $f\,(2H)/V=0.17$, where f is frequency, H is wall height and V is wind speed.

Influence of Adjacent Buildings to Wind

By Hatsuo Ishizaki and In Whan Sung

Proceedings of the 3rd International Conference on
Wind Effects on Buildings and Structures,
September, 1971, pp. I. 15–1–8 (in English).

Abstract

In the design of a high-rise building a new problem on winds, other than the wind loading on the building, has arisen. It is the prediction of the modification of airflow around the new building to minimize the effects of the new building on the existing ones and pedestrians on the street.

The purpose of this paper is to show the results of wind tunnel experiments on the modification of air flow between two identically shaped model-buildings, which is the first step of a research program to study the modification of airflow characteristics by structures.

The wind speed in the gap between two buildings shows the maximum value at a certain separation distance. The maximum value of the relative wind speed (the ratio of the disturbed and undisturbed wind speed at the same height) observed in this experiment was 1.4 and this value decreases with increase of width of the model buildings and also with increase of length of them.

When the gap becomes narrower than the critical separation, the relative wind speed decreases rapidly in almost cases except the cases in which the length is twice as large as the width. In such cases it increases again at the bottom of the gap.

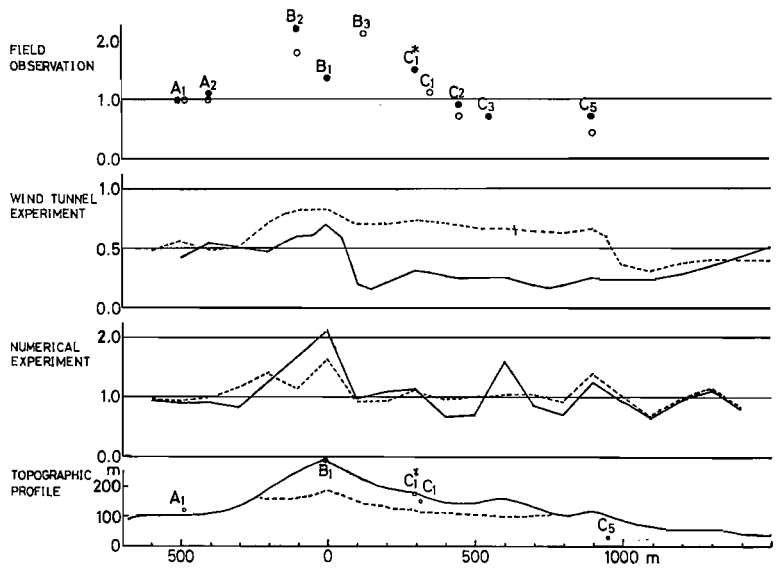
A Case Study of Wind over a Hilly Terrain

By Yukihiro MORI, Kenji MIYATA and Yasushi MITSUTA

Bulletin of the Disaster Prevention Research Institute, Kyoto University, Vol. 21, Part 2, No. 190, November, 1971, pp. 179–189 (in English).

Abstract

A case study of modification of airflow over small scale undulation of topography is presented. The target area chosen for this study is the area around Mt. Takakura, Kobe City, because this mountain of about 300 m high was cut down to a plateau of about 150 m high as the result of a large civil engineering work in the period of the field observation. Besides the field observation for about a six year period, the modification of airflow over this area was also studied by wind tunnel and numerical experiments for both topographies before and after the engineering work. The results of these three methods of study resemble each other in the general feature of airflow patterns but quantitative predictions by the experiments are still incomplete. As the result of the present study, it was concluded that the effect of the removed hill body was restricted to the small area just near the mountain. An example of the results is shown in the next figure.



Comparison of the results of the three kinds of approach for the study of the topographic effects on airflow over Mt. Takakura in the case of westerly wind, along the line parallel to the wind passing the mountain top. Wind speed is scaled as the relative value to the one at the reference point A_1 on the windward side. The white circle and solid line show the state before the work and the black circle and dotted line show the case after the hill was cut down as shown at the bottom.

Characteristics of Airflow over the Barriers in the Storm

By Yasushi MITSUTA

Proceedings of the 3rd International Conference on Wind Effects on Buildings and Structures, Tokyo, September, 1971, pp. I. 4-1-12, (in English).

Abstract

Recently, Vraious kind of structures, such as observatories, ardio antennae and electric power lines, are becomming to be constructed on sites with complex topography. For the design of these structures, knowledge of wind characteristics over irregular terrain are especially important. The results of storm wind observations over the small barriers of about a few kilometers with typical topographic features are presented, and the characteristics of airflow over a complex topography are discussed in contrast with wind characteristics over flat uniform land.

The first example is the result of wind observations over the Naruto Straits at the southeastern opening of the Seto Inland Sea. The narrow but bluff capes strech from the both sides of the channel, forming a narrow gap of about 1.2 km in width between them. Strong wind was observed in this gap when the wind direction is parallel to the channel. At the point of the cape, the strongest wind speed, which is as high as 2.2 times of that of undisturbed flow, is observed. The distribution of wind speed in the cross section of the gap and its variation with wind speed and stability are discussed.

The second example is the result of wind observations on Mt. Kasatori. The spectrum of wind fluctuation on the long extending ridge of about 700 m high is quite different from that over the flat land, and wind characteristics are greatly influenced by small scale mountain topography. The fluctuations at two adjacent points on the ridge are less correlated than is the case over the flat land. The mean wind inclination on the slope varies with wind speed and is not zero even on the ridge. The spectrum of the fluctuations of wind inclination on the slope shows an apparent peak, which is not seen on the wind speed spectrum in the high frequency part at about 0.3 cps in a wind of 7 m/sec.

The Mechanism of Shearing and Its Similarity for Sands and Clays

By Sakuro MURAYAMA and Hajime MATSUOKA

Annuals, Disaster Prevention Research Institute, Kyoto University, No. 14B, April, 1971, pp. 551–563 (in Japanese).

Abstract

Sand is an assembly of particles, therefore its mechanical properties should reflect the microscopic behavior of the individual particles. It is also seen that clays, which consist of very fine particles, show a granular property such as dilatancy. The granular nature of soils found in sands and clays should be one of the most essential properties of soils. Therefore, the shearing mechanism of granular soils such as sands and gravels have been studied from the microscopic point of view in order to analyze their macroscopic stress-strain relation. For this purpose, special shearing tests were carried out using rod masses piled horizontally with aluminium rods with various diameters or similar rods made of a photoelastic material in order to simulate granular mass in a two-dimensional state. From these experiments, the angle between contact plane of particles and potential sliding plane of rod mass θ, the interparticle force f and the frictional angle between particles δ were adopted as essential factors which control the shearing resistance of soils. The concpet of "the frequency distribution of θ" and its variation during shear were introduced in order to represent the macroscopic shearing resistance- and dilatancy-characters.

In this paper, the relation of stress ratio (τ/σ_N) and strain-increment ratio $(d\varepsilon_N/d\gamma)$ on the potential sliding plane is derived from these microscopic considerations as follows:

$$\tau/\sigma_N=\lambda(\mathrm{d}\varepsilon_N/\mathrm{d}\gamma)+\mu$$

where $\lambda=1.4\sim1.5$ (const.), $\mu=\tan\delta$ and $\bar{\theta}$; the mean value of the frequency distribution of θ just after shearing starts. By comparing the data obtained by simple shear tests and triaxial tests with the above result, it is found that this relation is applicable not only to loose and dense sands but also to normally consolidated clays and over-consolidated clays. These experimental results also suggest the exixstence of similarity between the shearing mechanism of sands and that of clays, therefore the above-mentioned relation may be expected to be a fundamental rule which controls the shearing behavior of soils. Furthermore it is made clear that this stress ratio and strain-increment ratio relation is related to the stress~dilatancy theory of P. W. Rowe.

Fractured Zone Type Landslide and Electrical Resistivity Survey (1) — On the Usefulness of the Electrical Resistivity Survey at the Fractured Zone Type Landslide Areas —

By Atsuo TAKEUCHI

Bulletin of the Disaster Prevention Research Institute,
Kyoto University, Vol. 21, Part 1, No. 185,
September, 1971, pp. 75–98 (in English).

Abstract

The usefulness of electrical resistivity surveys at the Tertiary type landslide areas has been shown by Dr. Takada. So the author has considered to what extent the elctrical resistivity surveys could be useful at other types of landslide area. If the usefulness of electrical resistivity surveys could be shown for other types, many valuable data could be obtained to make clear the displacement mechanisms of landlisdes. Thus effective preventive engineering works coudl be undertaken, while expenses for such investigations and preventive engineering works would be much reduced.

At present, at landslide areas other than the Tertiary type, electrical resistivity surveys are little used. So the author has examined the usefulness of the electrical resistivity survey at the fractured zone type landslide areas which are of very frequent occurence, after those of the Tertiary type. Landslide areas examined were the Wada landslide area, belonging to the Mikabu green rocks zone; and the Choja landslide area, belonging to the Chichibu zoning Kurosegawa tectonic line. The results of these electrical resistivity surveys gave the following valuable information:

1. Outline of the form of the bedrock and slide layer
2. Existence and condition of underground water
3. Some hypothesis as to the landslide displacement mechanism
4. Estimate of effectiveness of landslide preventive engineering works emphasising underground water drainage

Hence, it is clear that the usefulness of electrical resistivity surveys on the fractured zone type landslide areas has been established.

Accordingly, when landslide investigations are to be make, an electrical resistivity survey should be carried out at the first step in any such investigation. After getting the above-mentioned information, further landslide investigations and landslide preventive engineering works can be carried out more effectively and at less expense.

Fractured Zone Type Landslide and Electrical Resistivity Survey (2)
— Information Obtained from Electrical Resistivity Survey —

By Atsuo TAKEUCHI

Bulletin of the Disaster Prevention Research Institute,
Kyoto University, Vol. 21, Part 2, No. 188, November,
1971, pp. 137–152 (in English).

Abstract

The usefulness of the electrical resistivity survey in the fractured zone type landslides were examined at the Choja and the Wada landslide areas in Kochi Prefecture. Results show that electrical resistivity surveys could be satisfactorily applied in the fractured zone type landslide areas as well as in the Tertiary types, and that much information could be obtained by electrical resistivity surveys.

A thorough survey was therefore conducted to determine its positive efficiency at many other fractured zone type landslide areas in Kochi Prefecture. The following results were obtained:

1. From the assumed diagram of the underground stracture;
   a. An outline of the underground structure of the investigated landslide area.
   b. Fairly exact information on the form and existing depth of bedrock surface and slide surface.
   c. The landslide area can be divided into blocks due to the area's topographical map plotted by the discontinuity belts of the resistivity values seen from the assumed diagrams of the underground structure profiles.
   d. Even if the bedrock exists so deeply that its depth cannot be determined by an electrical resistivity survey, the shallow slide layer which caused damaged to land and property was sufficiently detected.
2. From the analyzed results of the horizontal electric profiling;
   a. It is assumed that the distributed areas of the low apparent resistivity values belong to one of the (follwing) areas; the existence of abundant underground water, present active landslide areas, weather exposed areas of soil mass, and areas where possible landslide movement may occure in future.
   b. Within in the distributed area of low apparent resistivity values and discontinuity belts of resistivity values of underground structures, the landslide area can be divided into blocks. These blocks have an important relation to landslide movement.

Underground Temperature Survey in and around the Landslide Area (1)
— A New Investigation Method of Underground Water —

By Atsuo TAKEUCHI

Bulletin of the Disaster Prevention Research Institute, Kyoto University,
Vol. 21, Part 3, No. 192, January, 1972, pp. 201–216, (in English).
Jisuberi, The Japan Society of Landslides, Vol. 8, No. 3,
February, 1972, pp. 3–12 (in Japanese).

Abstract

It goes without saying that the underground water existing in and around the landslide area plays a very important role as a trigger of the occurrence of landslides. Accordingly, information pertaining to the underground water in and around the landslide area is required in the event of prevnetive measures to be considered.

The matter which must be clarified about the underground water in the beginning, is the route of supply of underground water to the landslide area. It is necessary to clarify the routes and kinds of the underground water and to obtain information concerning the effect on the landslide movement. When these points are clarified, the degree of contribution of the underground wtaer to the landslide movement can be estimated, and the appropriateness of preventive measures based on information concerned with the underground water can be judged. If this work is judged to be pertinent, we can discuss the most effective and reasonable method for conduction of the underground water and important data will be offered for planning landslide preventive measures.

In this way, the investigations related to the underground water occupy an important position in landslide investigations. Nevertheless, it seems that the tracer method of the underground water conducted at present has imperfect points. Thus, the author inquired into the imperfect points from the existing condition of underground water in and around the landslide area. As a result he realized the necessity of carrying out a new underground water investigation method before conducting the existing tracer method.

From discussions of the existing condition of underground water in and around a landslide area, it was suggested strongly that the underground water connecting with landslide activity existed in vein-stream form rather than as stratiform in the landslide area. If the underground water exists as vein-stream form in the landslide area, a satisfactory result is not likely to be obtained by using the existing tracer method. So it is considered a good method if we presume the existing place of the vein-stream by some other method before conducting the costly tracer method and we then could conduct the tracer method to obtain its precious data only for the confirmation of the vein-stream. As one of the favorable methods of the vein-stream investigation, the underground temperature survey was conducted in the Kamioogi landslide area in Shiga Prefecture. From the result, this survey showed a large possibility for obtaining useful data concerning vein-atreams. The merits of the survey were as follows; the survey could be done within a short period by relatively simple methods and at small expense. These merits are important considerations for preparatory investigation.

Synthetic Observation on Rock Mudflow

By Setsuo OKUDA, Hiroshi SUWA, Kōji YOKOYAMA
and Hisashi EDAGAWA

Journal of the Japan Society of Photogrammetry,
Vol. 11, No. 1, March, 1972. pp. 13–20 (in Japanese).

Abstract

It is very important for our country to survey physical processes of rocky mudflow which cause serious damage in mountainous regions. In order to carry out a systematic and exact observation on the moving state of rocky mudflow, a new synthetic observation system was developed by the Mudflow Research Group.

The system consists of velocity sensors connected with a time recorder for the measurement of local variation of front velocity and 8 mm cine camera, 16 mm cine camera, 35 mm constant time interval shot camera, video camera and stereo cameras, which are ready for automatic recording of the moving pattern and form of mudflow.

In addition to the system, rain gauges and mud samplers were set in the same observation area to survey water balance and the physical property of flowing substance.

After a preliminary test in 1970, a field test of the whole system was carried on in 1971 at Valley Kamihori on eastern slope of Mt. Yake, North Japan Alps, Nagano Pref.

In the morning on 6th, Sept. 1971, our new system succeeded in recording the motion of rocky mudflow several times, and valuable information about mudflow was obtained in relation to hydrological and micro-topographical conditions.

Important results from this observation are as follows.

(1) Occurrence time of mudflow coincides with peak time of rainfall intensity averaged in a 10 minute period.

(2) Observed front velocity of mudflow ranges from 3.3 to 7.7 m/s corresponding to slope gradient and flow scale. Change in flow speed can be hardly found in the course of passing over a debris control dam.

(3) Level surveying of the valley profile before and after the mudflow shows a severe scouring over 5 m in upper reach, wide deposition area along lower reach and alternate distribution of erosion and piling region at intermediate reach.

(4) Particle size analysis of mud which was collected from mudflow front by samplers show a wide range of diameter, 0.01–5 mm as well as a large median diameter of 1 mm.

Predicting the Effect of Urbanization of a Hill Area on Flood Runoff

by Mutsumi KADOYA, Taro OKA and Yoshio HAYASE

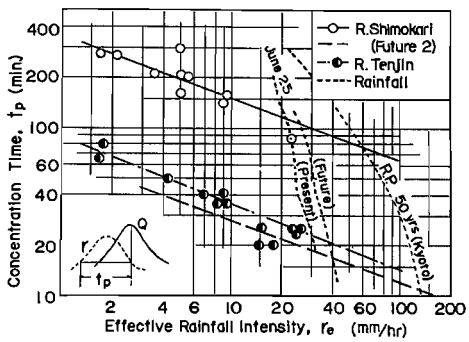
Proceedings of the 8th Japan National Congress for Natural Disaster Science, October, 1971, pp. 107–110 (in Japanese).

Abstract

The effect of urbanization of a drainage basin on flood runoff was discussed predictively in the Shimokari River Basin of 1.32 km^2. The upper one half of the basin consists of Paleozoic rock covered with miscellaneous bushs. The middle one-third is composed of so-called Osaka Formation where thick bamboo groves are to be found. The lower area, composed mainly of alluvial bed, is utilized as a farm. There is a plan for urbanization of the basin in the near future. A predictive study was then carried out on the basis of runoff data observed at the outlet of the basin.

The upper real line in the figure shows the relation between the effective peak rainfall intensity, r_e, and its concentration time, t_p. From this relation, the equivalent roughness, N, defined in the kinematic wave method for runoff analysis was estimated as $N=0.6\sim0.8$ (m$^{-1/3}$sec) in a slope surface of a sub-basin in the basin. The effective rainfall component for direct runoff was evaluated by a form of the curve for cumulated rainfall and loss. Runoff analysis was carried out using these data and applying the kinematic wave method to simulate runoff hydrograph, and the result was good in the sense of engineering practice.

The effect of urbanization on flood runoff was examined presuming changes in the effective rainfall component and the equivalent roughness. In presuming these values, the data obtained in an urban area of the Tenjin River Basin were referred. It was pointed out as the result that the runoff hydrograph should show rapid variations reflecting the variations of rainfall intensity in a short time. The lower broken line in the figure is one of the results.



Concentration time for runoff peak.

Experimental Studies on Water Particle Velocities Induced by Waves Using an Acoustic Current Meter

By Yoshito TSUCHIYA and Masataka YAMAGUCHI

Proceedings of the 18th Conference on Coastal Engineering in Japan, October, 1971, pp. 97–104 (in Japanese).

Abstract

To obtain the water particle velocities induced by waves is of great importance for the investigation of various phenomena on coastal engineering such as wave force, littoral drift and so on.

This paper deals with the experimental investigations on the validity of theoretical expressions for horizontal and vertical water particle velocities induced by regular waves and by wind waves.

Firstly, water particle velocities induced by regular waves were measured using a Doppler-type acoustic current meter on a sloping beach of which the slope is 1/100, including near breaking waves. The validity of wave theories such as Stokes and cnoidal waves is investigated by comparison between the theoretical curves and the results of experiments. It is found that these theories predict well the water particle velocities in the case of relatively large values of h/H, where h is the depth of water and H the wave height, but that the deviation of both the results becomes greater with the increase of wave height because of the poor response of the current meter and the lack of the degree of approximation for these theories.

Subsequently, experiments on water particle velocities of wind waves generated by a recirculating wind wave tank were carried out. Auto-spectra of surface displacement and water particle velocities and cross-spectra between them are considered. In consequence, a method of estimation of water particle velocities induced by wind waves is proposed, introducing the correction coefficients.

In addition, some examples on the observations of water particle velocities of ocean waves in shallow water are presented.

On the Characteristics of Saltation of Sand Grains

By Yoshito TSUCHIYA and Yoshiaki KAWATA

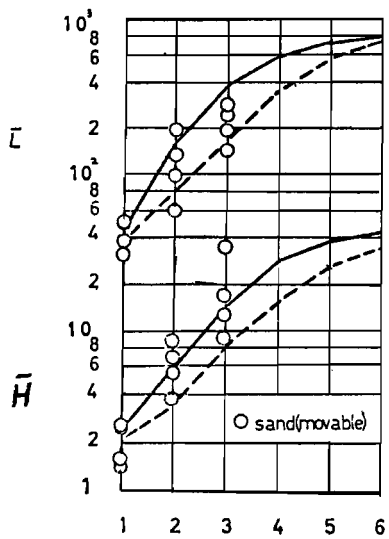
Proceedings of the 18th Conference on Coastal Engineering
in Japan, October, 1971, pp. 359–364 (in Japanese).

Abstract

In the sand storms, the sand grains on the sand bed are moved by aerodynamic forces. After rolling and sliding for a distance less than a grain diameter, the sand grain comes into collision with other sand grains and then begins jumping motion. Such a motion is considered as saltation and the various characteristics, such as the saltation height, distance and others, are experimentally made clear using a high speed camera and a film motion analyzer. The results of the experiment are considered in comparison with those of sand transport in water and analyzed by the theory of successive saltation proposed by the authors.

It was first found by the analysis of the path of sand grains in a saltation layer that there exists an active exchange between the saltating sand grains and the sand grains on the bed. Therefore, a detailed discussion of the changes of parameter characterizing the sand bed condition with the order of saltation and with the increase of flow intensity is made. The saltation height and distance increase, rapidly with the order of saltation in comparison with those in water. It seems quite reasonable to expect that the effect of the rebound coefficient of the sand grain is significant in the saltation because the coefficient is about 0.72 in air but about 0.5 in water. It was concluded that the theoretical curve of changes in saltation height and distance with the order of saltation is in good agreement with the experimental values in successive saltation as shown in the figure. Furthermore, when successive saltation is continued, the height and distance of saltation seem to approach the theoretical curves for stationary saltation.

The distributions of saltation height and distance are generally skewed on the small side of height and distance, which is similar to those in water. It was pointed out from the experimental results that the concentration of saltating sand grains in a saltation layer decreases with the distance from the bed but not exponentially.



Comparison between theoretical curves of slatation height and distance and experimental ones,

Effect of River Discharges upon Transformation of Tsunamis in Kochi Harbour Model

By Shigehisa NAKAMURA

Proceedings of the 18th Conference of Coastal Enginereing in Japan, October, 1971, pp. 229–233 (in Japanese).

Abstract

This is a continuation of the model experiment on tsunami in Kochi Harbour. The effect of river discharges pouring into the harbour is studied in relation to a problem of transformation of tsunamis propagating into the harbour by the use of the hydraulic model which has been used for the experimental study of tsunamis.

The effect of the tsunami breakwaters is studied for the given condition, that is, a design tsunami assumed to propagate into the harbour where a design flood flow is found. The crest height distribution of the design tsunami in the harbour is studied experimentally for the model of the future harbour plan. The wave height of the design tsunami is also studied. The result of the experiment shows that the wave height decreases in the harbour with the distance from the harbour mouth, and that the effects of the given flood flow and the tsunami breakwaters upon the transformation of the tsunami are significant in the harbour.

The quantitative appreciation of the effects in the harbour is evaluated by an application of the fundamental studies for interactions between waves and currents. Considering a wave height ratio at the harbour mouth and at a location 4 km distant from the harbour mouth, the decrement of the wave height in the harbour is found by the values of the ratio: 0.439 for the case with the breakwaters and 0.571 for the case without the breakwaters. And the effect of the breakwaters is evaluated as 0.770 (=0.439/0.571), when the flood flow is found in the harbour. When there is no river discharge, the effect of the breakwaters is evaluated as 0.484, which is different from the above value 0.770.

Experimental Study on Wave Overtopping of Obliquely Incident Waves on Vertical Seawalls

By Masao INOUE and Yoshito TSUCHIYA

Proceedings of the 18th Conference on Coastal Engineering in Japan, October, 1971, pp. 259–264 (in Japanese).

Abstract

As of this time although a few experimental results on wave run-up and wave overtopping of obliquely incident waves on seawalls have been obtained, these are unsatisfactory, in particular the effect of incident wave direction on the quantity of wave overtopping on seawalls is entirely unknown.

For this reason, some experiments were carried out to make clear the characteristics of three dimensional wave overtopping phenomena.

In this paper, the experimantal results on the wave overtopping of obliquely incident waves on vertical seawalls, insular breakwaters and near the corner of a seawall are presented.

The main results obtained from the experiments are summarized as follows:

1) The distributions of the quantity of wave overtopping along the normal line of the seawall are not uniform, vary complicatedly with the change of incident wave direction. If the wave height in front of the seawall is constant, the maximum of quantity of wave overtopping appears when the wave direction is normal.

The decreasing ratio of the quantity of wave overtopping caused by the angle α between the normal line of the seawall and the wave direction, $\mathbf{K}_\alpha$ is approximately expressed as $(1+\sin\alpha)/2$.

2) Also as to the wave overtopping on an insular breakwater, the distributions of the quantity of wave overtopping vary complicatedly with the incident wave direction as well as with wave height in front of the seawall. Especially, the distributions of the quantity of wave overtopping in the case of the incident angle of $\pi/2$ agree with not only the experimental results but also with the theoretical result obtained by Mitsui on the distributions of wave height.

3) As to the wave overtopping near the corner of seawall, the minimum of the quantity of wave overtopping appears at the corner of the seawall, on the other hand, the maximum appears at a certain position a little away from the corner, for all of the incident wave directions.

Horizontal Water Particle Velocity of Finite Amplitude Waves

By Yuichi IWAGAKI and Tetsuo SAKAI

Proceedings of the 12th Conference on Coastal Engineering,
September, 1970, pp. 309–326 (in English).

Abstract

The water particle velocity induced by surface waves is one of the most important factors to solve the wave breaking mechanism, wave forces acting on submerged structures, mechanism of suspension and diffusion of materials by waves, and so on. However, there have been very little experimental data, because of the difficulty of the measurement.

Recently, a new method to measure the water particle velocity was proposed, which is by using hydrogen bubbles as tracers; that is, tracing motions of hydrogen bubbles generated in water by electrolysis every very short period to measure the water particle velocity induced by waves. This method is used to measure the vertical distribution of the horizontal water particle velocity under the wave crest. On the other hand, the time variation of the horizontal water particle velocity during one wave period at a definite height from the tank bottom is measured with two hot film anemometers, which were primarily developed for turbulence measurements in water.

This paper presents the experimental results of the horizontal water particle velocity obtained by these two methods, as well as comparison with theoretical values calculated from the small amplitude wave theory, Stokes wave theory of 3rd order, and the hyperbolic wave theory as an approximate expression of the cnoidal wave theory of 2nd approximation. Based on the comparison between the theories and the experiments, the applicability of the finite amplitude wave theories for the water particle velocity is discussed.

The conclusions are as follows:

(1) The region, where the hyperbolic wave theory should be applied to the horizontal water particle velocity rather than Stokes wave theory, is $T\sqrt{g/h} \geqq 10$, which was found for its vertical distribution under the wave crest, and $T\sqrt{g/h} \geqq 14$ for its time variation during one wave period.

(2) It should be noted that, in computing the wave force acting on submerged structures, Stokes wave theory may give too small values of the horizontal water particle volocity at the water surface in the region $T\sqrt{g/h} \geqq 10$.

A Study on Nonlinear Interactions of Waves in Experiments of Wave Reflection

By Yuichi IWAGAKI and Akira KIMURA

Proceedings of the 18th Conference on Coastal Engineering in Japan, October, 1971, pp. 105–109 (in Japanese).

Abstract

Reflection of water waves is associated with problems of the interaction between waves and structures. In most cases, the reflection coefficient cannot be predicted theoretically but must be obtained experimentally. Recently two new methods were proposed to obtained the accurate reflection coefficient of water waves. One is an attempt to pick up the profile of reflected waves from standing waves, by using an electrical circuit of subtraction and other is a method to correct the reflection coefficient obtained by the experiment using Healy's Method, based on the finite amplitude wave theory.

In the present study, composite waves were generated to learn the reflective characteristics of irregular waves. A smooth plate was used as the reflecting vertical object, which was capable of moving up and down. First of all, incident waves were measured without the plate by a wave gauge of electric resistance wire type, and then standing waves at the same point with the reflecting plate. The method of Fourier analysis was used to obtain the component wave heights of composite waves and compute the reflection coefficient of each component wave. The reflection coefficients obtained were scattered very widely even in the simple case of this experiment.

This paper discusses the reason for the scattering of experimental data, and showes that it may be due to the nonlinear interaction of component waves.

Conclusions obtained are as follows:

(1) The phase velocity of each component wave contained in composite waves is modified by the presence of other component waves. When two or more wave trains progress in the same direction, the phase velocity of each wave increases due to the interaction of waves. If the directions of propagation are opposite, the phase velocity of each wave decreases. This increase or decrease of wave velocity gives rise to the apparent change of the frequency of each component wave.

(2) Owing to the phenomenon that the apparent frequency changes gradually, it is very difficult to find the accurate amplitude of component waves by Fourier analysis method. Although the apparent change of frequency is very little, its effect on the component wave height is large.

(3) The experimental value of the reflection coefficient obtained by using the electrical circuit of subtraction is larger than the exact value.

On the Vertical Distribution of Water Particle Velocity Induced by Waves on a Beach

By Yuichi IWAGAKI, Tetsuo SAKAI and Takeshi KAWASHIMA

Proceedings of the 18th Conference on Coastal Engineering in Japan, October, 1971, pp. 93–96 (in Japanese).

Abstract

Many investigations on the phenomena of wave transformation in shoaling water exist, and the changes of wave height, wave celerity and wave length are explained well by using the assumption that the energy flux of waves is kept constant. However, although the water particle velocity induced by waves is one of the most important factors to solve the wave forces acting on submerged structures, mechanism of suspension and diffusion of materials by waves, and so on, there have been very little investigations as to the change of the water particle velocity fields in shoaling water.

The purpose of this study is to clarify the change of the water particle velocity fields induced by waves progressing in shoaling water and breaking finally. The vertical distributions of the horizontal water particle velocity at phases of wave crest and trough on a beach of constant slope (1/20) and at breaking were measured by the method of tracing hydrogen bubbles. The experimental results were discussed in comparison with the changes of wave height, wave profile and values of finite amplitude wave theories of uniform depth.

As characteristic quantities of the vertical distribution of the horizontal water particle velocity u, the following three parameters are selected: 1) the mean value $\overline{u_c}/\sqrt{gh}$ (h: water depth) over the vertical direction of u at the phase of wave crest, 2) the ratio of $\overline{u_c}$ to the mean value $\overline{u_t}$ of u at the phase of wawe trough and 3) the mean slope of u_c in the region where u_c is larger than $\overline{u_c}$ near the water surface.

The conclusions are as follows:

(1) The measured profile of water particle velocity under the wave crest agrees roughly with the theoretical curve of Stokes waves, but are very different from that of hyperbolic waves. Especially the experimental values near the water surface are much smaller than the theoretical values of hyperbolic waves.

(2) All of the three parameters become large in shoaling water, and with increase in the deep-water wave steepness for the same value of h/L_0 (L_0: deep-water wave length).

(3) The above mentioned experimental behaviours agree with the theoretical ones of Stokes waves, but the values of $\overline{u_c}/\sqrt{gh}$ and $\overline{u_c}/\overline{u_t}$ are smaller than the theoretical ones.

On the Finite Amplitude Long Waves on Uniform Slope Beach

By Yuichi IWAGAKI and Tetsuo SAKAI

Proceedings of JSCE,
No. 196, December, 1971, pp. 65–74 (in Japanese).

Abstract

Many aspects of the transformation of shoaling waves, such as wave height, wave celerity and wave length change, are explained well by using the assumption that the energy flux of waves is kept constant in shoaling water. However, the phenomenon that the wave profile becomes asymmetric near the breaking point and the effect of beach slope on the wave height change can not be explained from constancy of the energy flux, which is calculated based on wave theories of uniform depth. These phenomena can be explained by the method of taking the presence of beach into account as the boundary condition and obtaining the solution.

This paper presents a general representation for shoaling of finite amplitude long waves on a beach of constant slope, which is a solution of the shallow water theory of the lowest order. The linear solution, which has been obtained previonsly, can not explain the wave height increase and wave profile deformation, but the non-linearity of this theory, in which the pertubation method is used, will be able to explain these phenomena. Further, in order to obtain the solution easily, Bessel functions are approximated with the asymptotic expansion by trigonometric functions. The applicable range of this theory is determined as $20 \leqq T\sqrt{g/h} \leqq 4\pi/i$ (T: wave period, h: water depth, i: beach slope) by the following two conditions: 1) the pressure is assumed to be hydrostatic, and 2) Bessel functions are approximated with trigonometric functions. The theoretical results are shown graphically, and compared with the existing experimental results.

The conclusions are as follows:

(1) It is shown theoretically that in shoaling water the height of waves of the same deep-water wave steepness becomes larger on the mild slope beach than on the steep slope beach.

(2) It is also shown theoretically that in shoaling water the wave profile becomes asymmetric, which agrees with the existing experimental results, and for the same ratio of water depth to deep-water wave length the wave profile becomes asymmetric with increase in the deep-water wave steepness and decrease in the beach slope.

Harbor Oscillations Induced by Composite Waves in Rectangular Basins

By Yuichi IWAGAKI and Hitoshi MURAKAMI

Proceedings of the 18th Conference on Coastal Engineering in Japan, October, 1971, pp. 235–239 (in Japanese).
Bulletin of the Disaster Prevention Research Institute, Kyoto University, Vol. 21, Part 4, No. 196, March, 1972, pp. 265–277 (in English).

Abstract

Resonance in a harbor occurs when the period of waves arriving within the harbor coincides with the natural period of the harbor. Harbor oscillations, therefore, are greatly affected by not only the wave height but also the period of incident waves. This fact is generally found by obtaining the response curve of the harbor for regular waves with various periods. Since, however, ocean waves have continuous energy spectra, the influence of wave components except that of the natural period of the harbor on the harbor oscillation must be investigated. Because there exists the possibility of unexpected wave amplification due to mutual interaction of waves in the harbor, especially for the composite waves in the same manner as the resonant interaction of progressive waves.

This paper presents the results of experiments on harbor oscillations induced by composite waves in rectangular basins with a constant depth. The experiments were carried out in a two-dimensional wave tank in which a fully open harbor model was installed. In order to obtain the constant wave height the wave period was kept constant through a series of the tests but the harbor length was variable. The wave records were taken at both harbor entrance and end, and the wave amplification factor, defined as the ratio of the wave height in a certain point to that of standing waves when the entrance was closed, was derived for both regular and composite waves by harmonic analysis.

It is concluded that the resonant characteristics due to composite waves in a harbor are different from those due to regular waves by mutual interaction between component waves, especially the nonlinear effect near resonance is very strong. It is necessary to find not only the theoretical solution involving the effect of the incident wave height on the wave amplification factor but also the method of estimating precisely energy losses at the harbor entrance and friction losses of boundaries to predict the wave amplification factor quantitatively.

A Note on the Energy Transfer from Wind to Waves

By Norihisa IMASATO and Hideaki KUNISHI

Contributions, Geophysical Institute, Kyoto University,
No. 11, December, 1971, pp. 71–76 (in English).

Abstract

The amount of the energy transferred from wind to waves is estimated from our previous experimental data. This was carried out by assuming that the wind waves dissipate the energy only due to molecular viscosity, and by estimating $\frac{\partial}{\partial x}(C \cdot E/2)$ $(\equiv R_I)$ from the distributions of mean wave height in the wind tunnel. It is considered from this estimation that the energy transfer from wind to waves is about 15% of that as the critical layer in the wind field $C \cdot \tau$, where τ is the total stress of wind, and C the phase velocity of waves. The "wave drag coefficient" γ_a^2 which relates to the "effective stress" for wave growth is also shown as a function of wind speed.

From the relation between R_I and energy dissipation R_μ, the following definition may be made concerning the regions in the generation and growth of wind waves;

(i) The initial tremor and the earlier stage of initial wavelet are the regions where $R_I < R_\mu$. Although the waves develop quite rapidly, the greater amounts of energy transferred from the wind are dissipated by the molecular viscosity;

(ii) The sea wave is the region where $R_I > R_\mu$ and the large amounts of the energy transferred from the wind is used to maintain and develop the wave motion;

(iii) The later stage of initial wavelet is the transitional region from the earlier stage of initial wavelet to the sea wave.

On the Hydraulic Model Experiment on the Tidal Current in Matsukawa-Ura Bay

By Haruo HIGUCHI and Masaaki TSUJI

Proceedings of the 18th Conference of Coastal Engineering in Japan, October, 1971, pp. 337–342 (in Japanese).

Abstract

The flow pattern and diffusion phenomena due to the tidal current in a very shallow estuary of present state and dredged state are studied through a hydraulic model experiment, for which Matsukawa-Ura Bay is used as the prototype. The effect of density, wind and waves are not considered.

The bay is 6.45 km^2 in area, which is connected with the Pacific Ocean by a narrow channel, of which the minimum cross-sectional area is 220 m^2, and the length about 500 m. The mean water depth in the bay is 124 cm, which is almost the same as the tidal range. Therefore, the non-linear effect is remarkable; the larger the amplitude at the bay mouth, or the smaller the mean water depth is, the smaller the amplitude ratio becomes and the larger the phase lag in the bay.

A distorted model with many wire nets as an artificial bottom roughness, of which the horizontal scale and vertical scale are 1/600 and 1/50 respectively, was constructed and a semidiurnal tide was provided for it. The water level was measured at six stations with the use of an electric resistance wave meter, the flow pattern by tracing many floats and the diffusion by dye concentration analysis with the use of a fluorometer.

The tide is well reproduced in the model including the nonlinear effect. The flow pattern is also well reproduced. The distribution of dyed water after thirty tidal cycles, which was initially only outside the bay, is almost similar to the distribution of chlorinity in the prototype. The diffusivity reduced through the mixing theory of tidal flushing by Arons-Stommel is 0.8×10^5 $cm^2 \cdot sec^{-1}$ in the present state.

After several water ways were dredged to intensify the infiltration of sea water into the inner part of the bay, the distortion of the tidal curve becomes smaller, the amplitude ratio larger, and the phase lag smaller. The velocity of tidal current in the flood becomes smaller and that in the ebb larger by about 10%, excepting in the water way, where the velocity is intensified to 150–170% of that out of the water way. The diffusivity becomes 1.3×10^5 $cm^2 \cdot sec^{-1}$ in the dredged state.

On the Local Flow Just Upstream of the Contraction of the Channel Section

By Tadashi UTAMI

Proceedings of the Annual Meeting for Hydraurics Research,
The Japan Society of Civil Engineers, No. 16, February, 1972,
pp. 37–42 (in Japanese).

Abstract

Just upstream of the channel section where the shape of the boundary changes abruptly, a strong vortex occurs near the channel bed, which may give rise to local scour. The behaviour of such flow is decided by the velocity distribution of approaching flow and the shape of the boundary. That is, the flow composing the vortex is supplied from main flow and the vorticity in the main flow is concentrated around the position of the vortex axis.

As for the flow around a pier set in the center of the channel, the flow pattern in the central section is calculated on the basis of Helmholtz' vorticity conservation law on the boundary condition that approaching velocity plofile is a sine curve and there exists a point sink at the position of the vortex axis.

As for the flow just upstream of the contraction wall such as a dike, two-dimensional analysis is made on the flow pattern model in the section parallel to the channel bed, in which the mass transport from one section to another is reduced to the source or sink line along the contraction wall.

Experimental study is also made in order to verify both these flow pattern models and the analytical results. The results obtained analytically show good agreement with the experimental results when the appropriate choice of a coefficient is made, which is to be decided by experiments.

On the Basic Characteristics of Turbulence in Free Surface Shear Flows

By Hirotake IMAMOTO

Proceedings of the Japan Society of Civil Engineers, No. 197,
January, 1972, pp. 83–91 (in Japanese).

Abstract

The characteristics of turbulence in free surface shear flows are investigated theoretically and experimentally. The results obtained are as follows.

1) The skewness factor of the velocity fluctuations of flow direction is negative in almost whole region except near the bottom. Contrasted with the velocity fluctuations of flow direction, the skewness factor of the turbulent component perpendicular to the flow direction is positive in almost the whole region.

2) The turbulence in open channel flows is to be treated as multi-structure, that is, the dominant scales such as flow depth, width, and the non-homogenuity of the channel are related to the structure of turbulence.

3) The power law of $-5/3$ for inertial sub-range and -3 for viscous sub-range are verified experimentally for the Eulerian wave-number spectrum of turbulence, and also the power law of -2 for inertial sub-range for the Lagrangian frequency spectrum.

4) Using the flow similarity which is known as the Reynolds number similarity, the Eulerian properties of turbulence in free surface shear flows are described in the form of a universal function expressed with flow depth, shear velocity and local mean velocity, that is,

$$\text{turbulence intensity: } \frac{u'}{U_*(\overline{U}/U_*)^{1/3}} \approx 0.36\left(\frac{z}{H}\right)^{-1/3}$$

$$\text{Eulerian mean scale: } \frac{L}{H(\overline{U}/U_*)} \approx 0.15$$

$$\text{energy dissipation ratio: } \frac{\varepsilon}{U_*^3/H} \approx 0.35\left(\frac{z}{H}\right)^{-1}$$

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